Energy deposition for intense muon sources (chicane + the rest of the front end)

Pavel Snopok

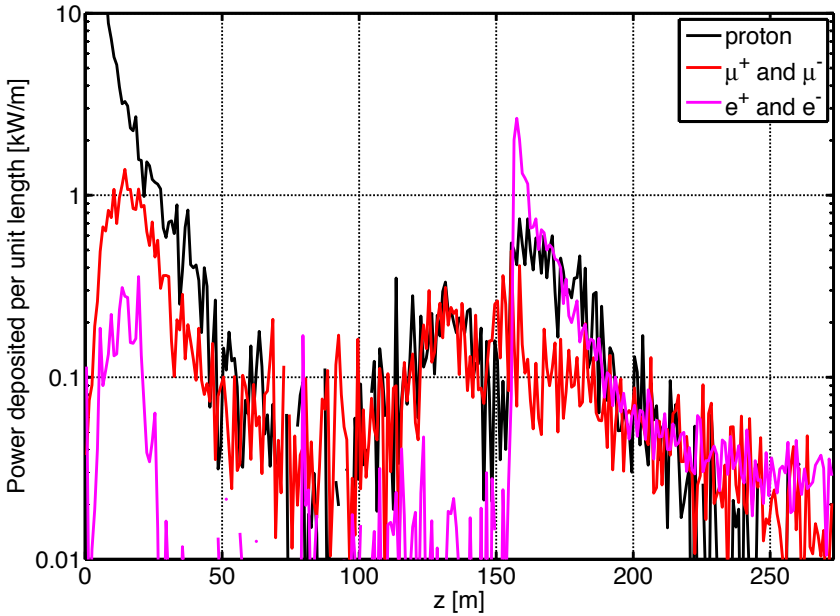
Illinois Institute of Technology and Fermilab

December 4, 2014

Outline

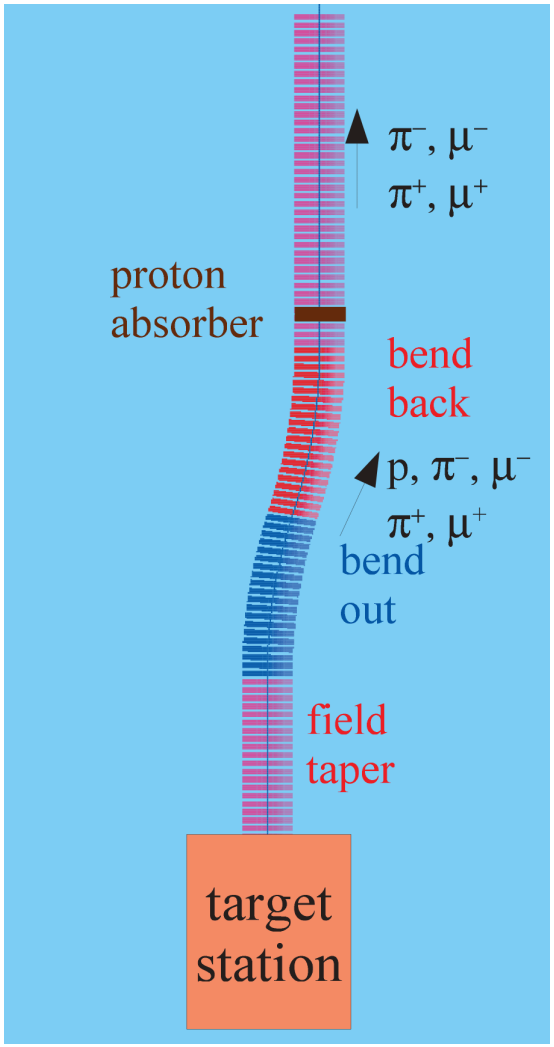
- Introduction
- History
- Current MARS simulations
  - new data files for solid target
- Using other codes (ICOOL and G4beamline)
- Summary

Introduction



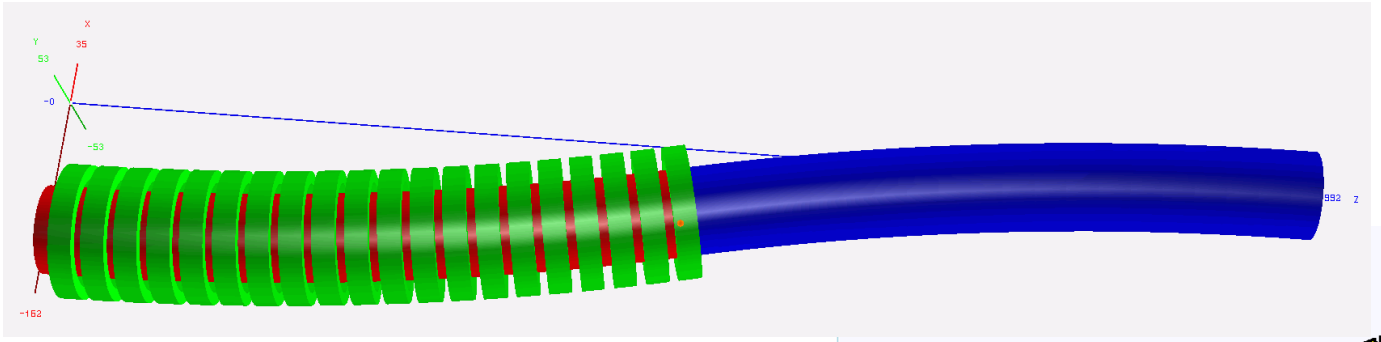
- In high-intensity sources muons are produced by firing high energy ***p*** onto a target to produce ***π***.
- ***π*** decay to ***μ*** which are captured and accelerated.
- Significant background from ***p*** and ***ē***, which may result in
  - heat deposition on superconducting materials;
  - activation of the machine preventing manual handling.

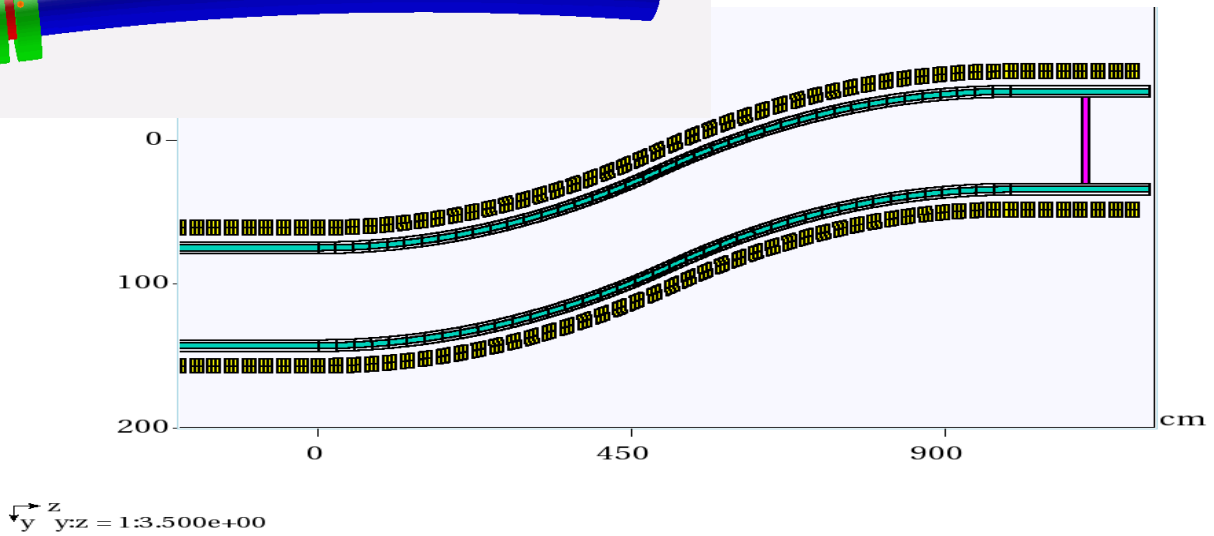
Introduction, contd.



- Need a secondary particle handling system for a megawatt class solid C target
  - solenoidal chicane
  - followed by a proton absorber.
- Challenges of optimization and integration of the system with the rest of the muon front end.
- Main study tool – MARS, some analysis and validation by using ICOOL and G4beamline.
- Start with the chicane, use the same technique downstream to study the the buncher and phase-rotator sections.

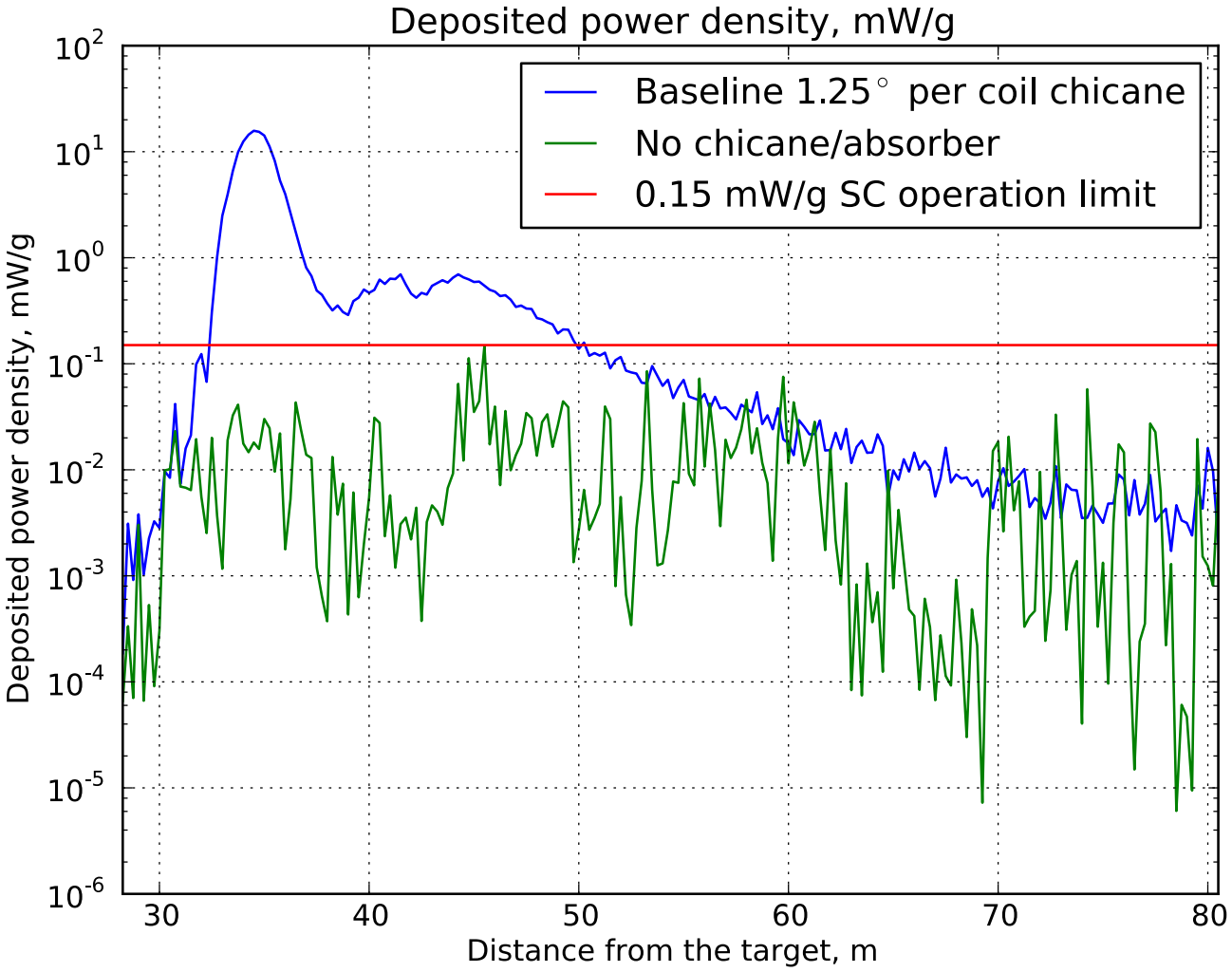
History: MARS simulations





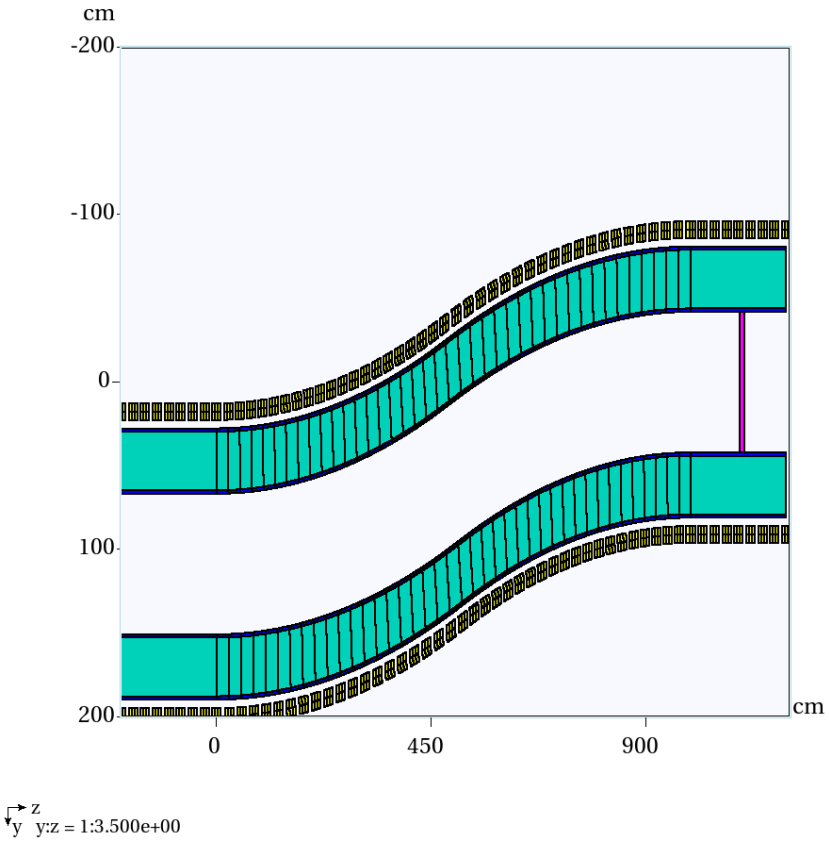
- ROOT-based geometry
- 12.5° single bend, Z=0 corresponds to 19 m downstream of the target
  - consistent with RDR (IDS-NF).
- W density reduced to 60% to take into account packing fraction for beads.

Reference: no shielding

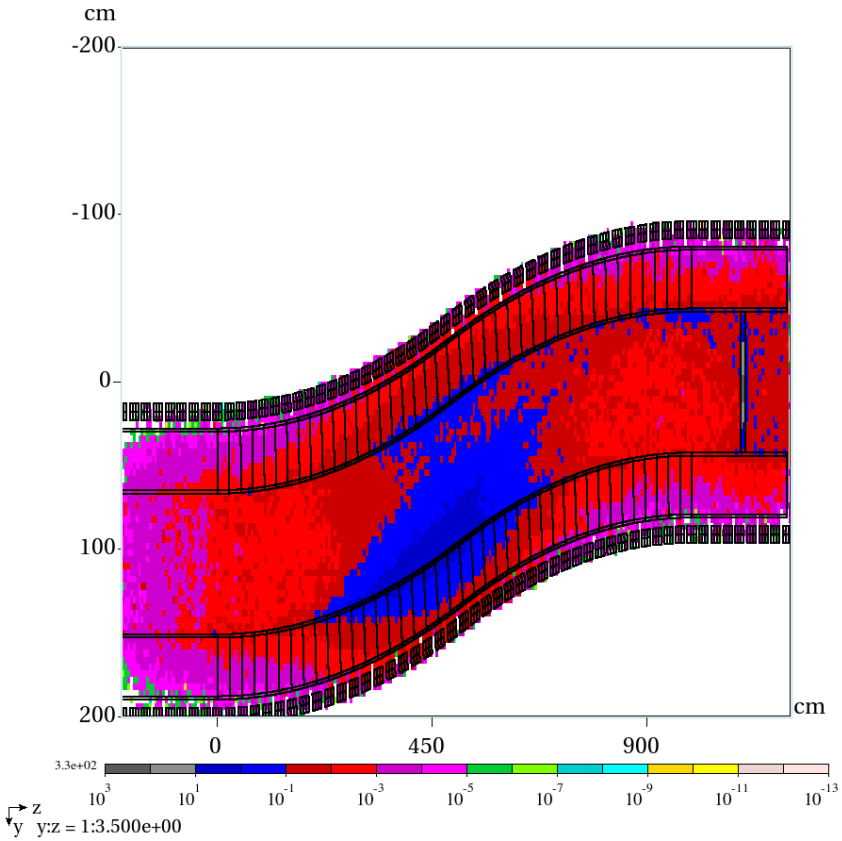


DPD peaks at 15.8 mW/g, that translates into 42.6 kW/m for Cu coils or 33.3 kW/m for SC coils.

Uniform 35 cm shielding

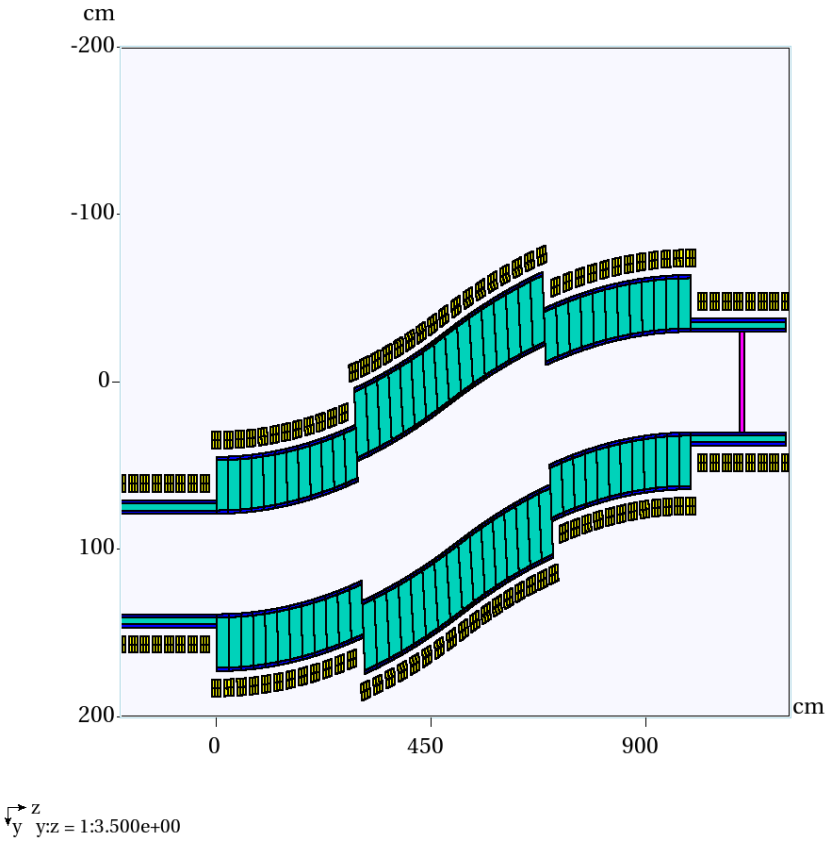


Empty channel

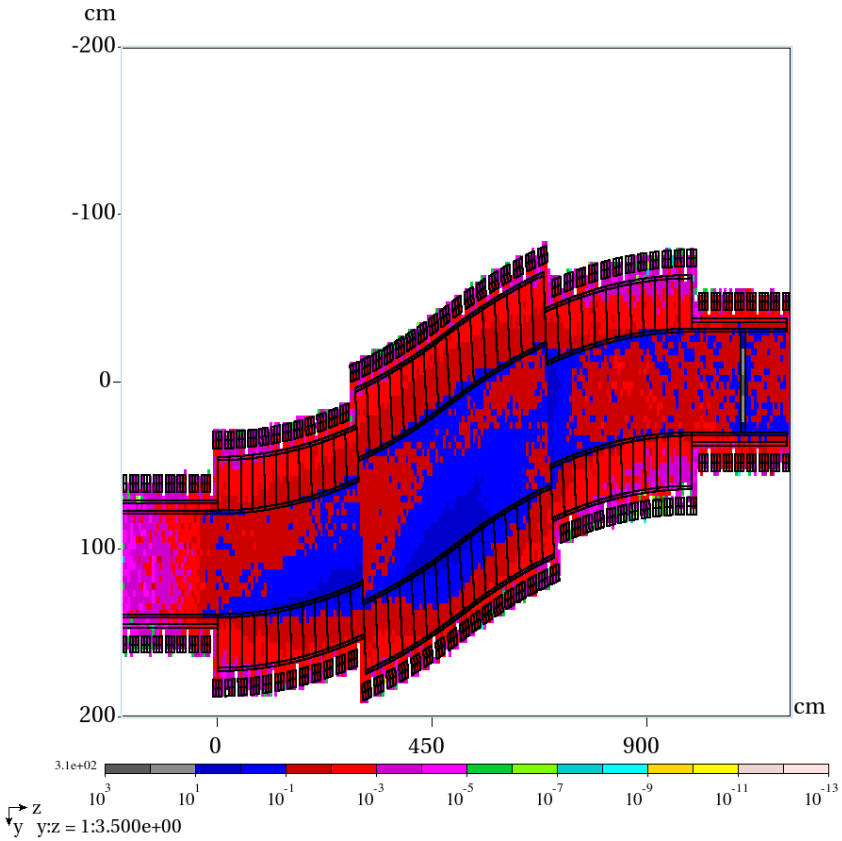


PD total, mW/g

Non-uniform 30 and 40 cm shielding

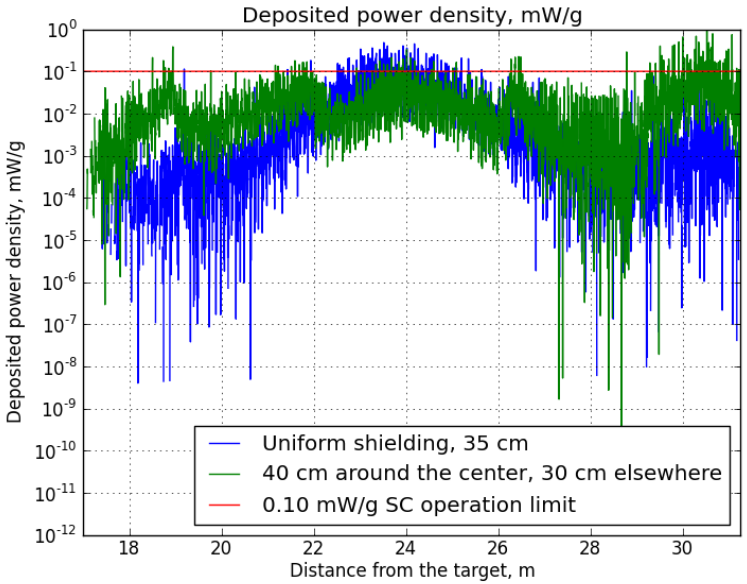


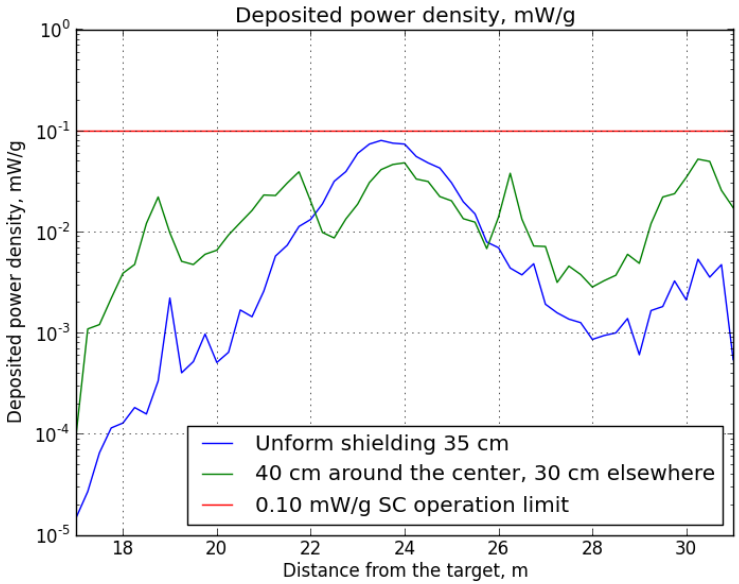
Empty channel



PD total, mW/g

Overall DPD per coil/segment





Segmented coil analysis, total DPD, mW/g

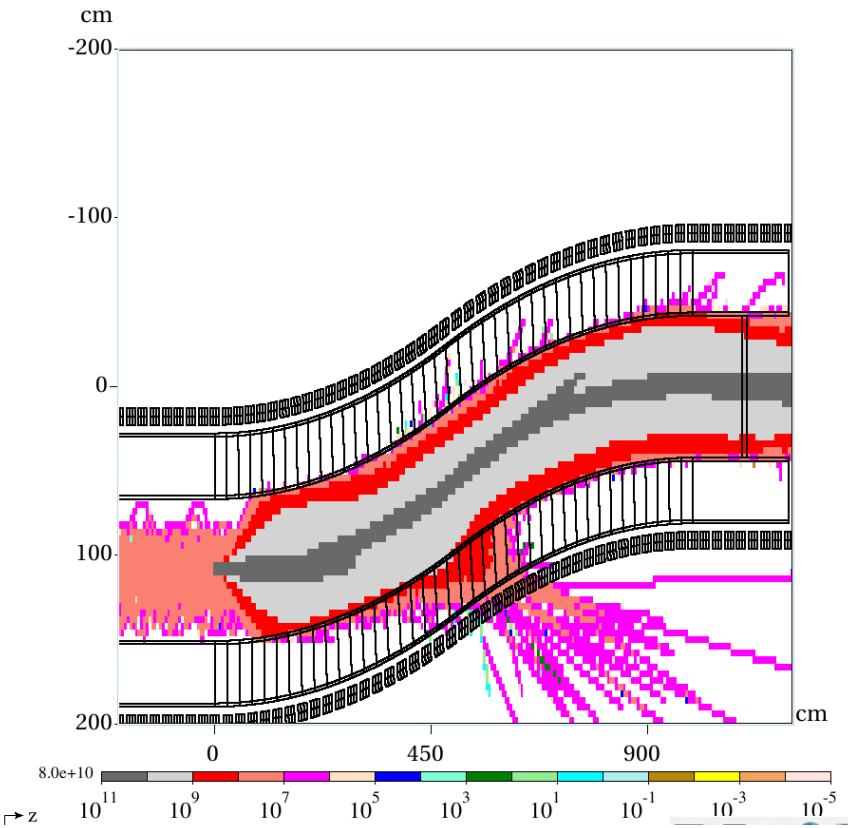
Average DPD per coil, mW/g

In both cases red line corresponds to 0.1 mW/g SC limit

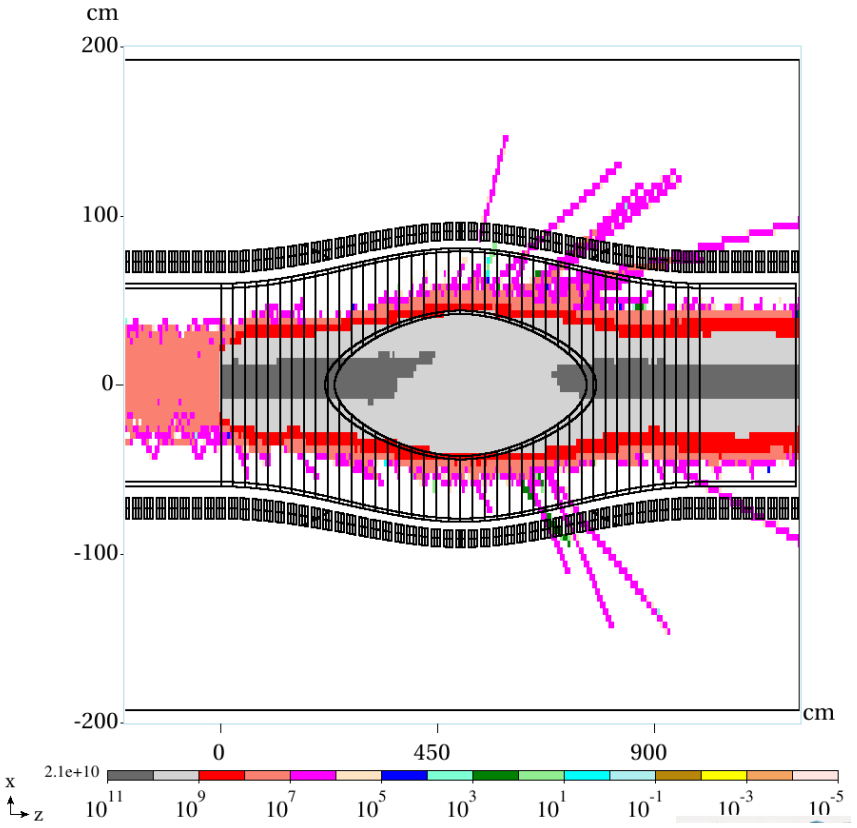
Current MARS simulations

- New target parameters:
  - 8 GeV => 6.75 GeV
  - 4 MW => 1 MW
  - 3.125e15 protons/sec => 0.925e15 protons/sec
  - new particle distribution
  - need to re-run MARS
- The hope is that the new parameters help reduce the amount of shielding required

New results

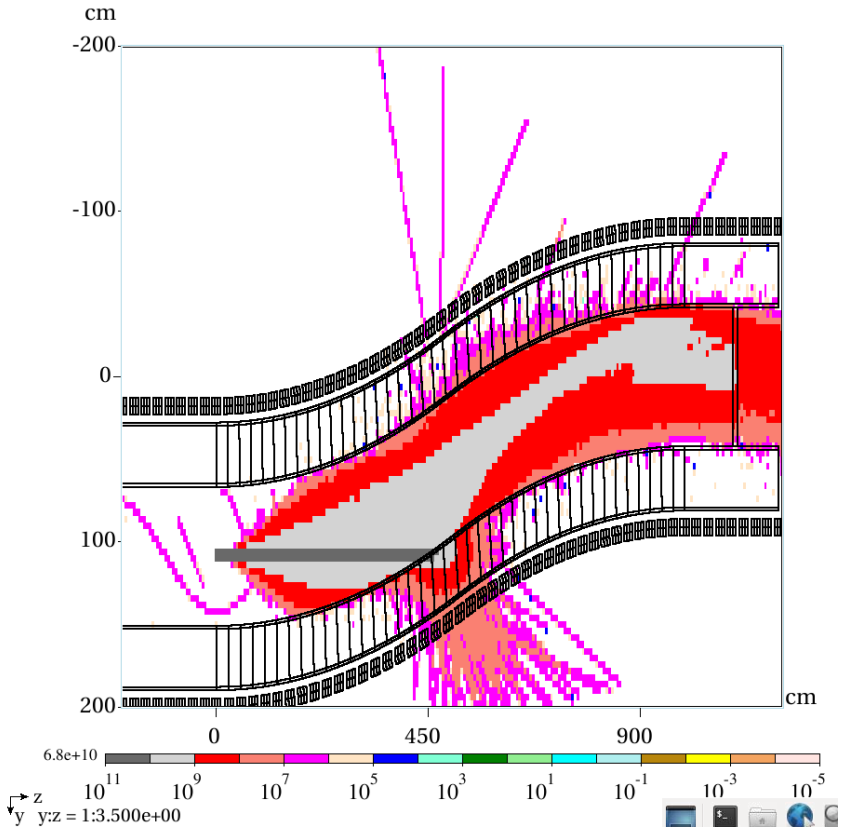


Muon flux, top view

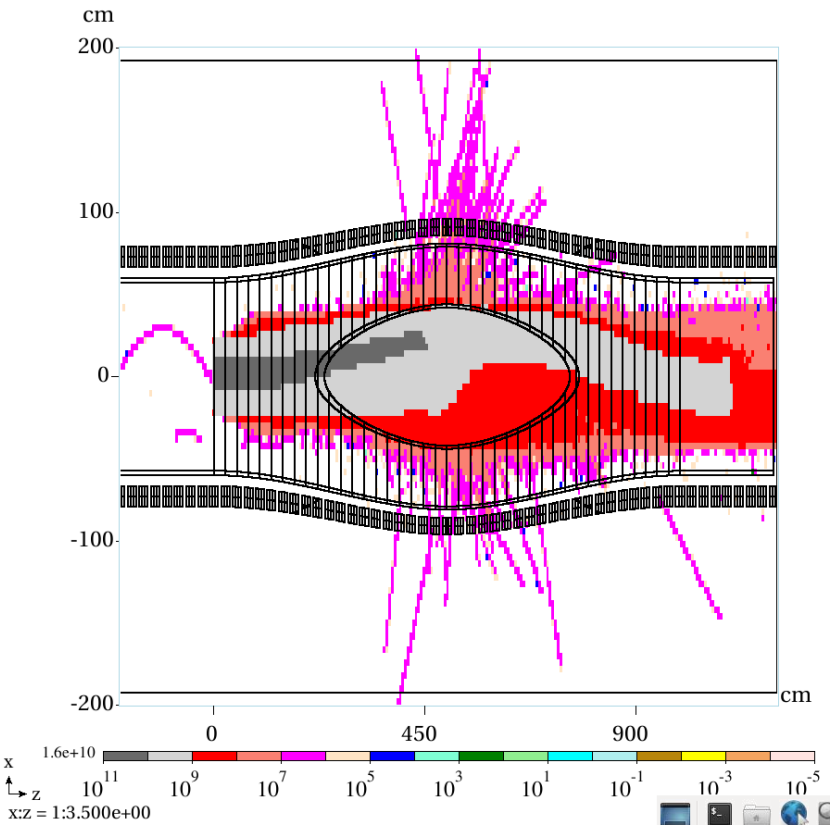


Muon flux, side view

New results 2

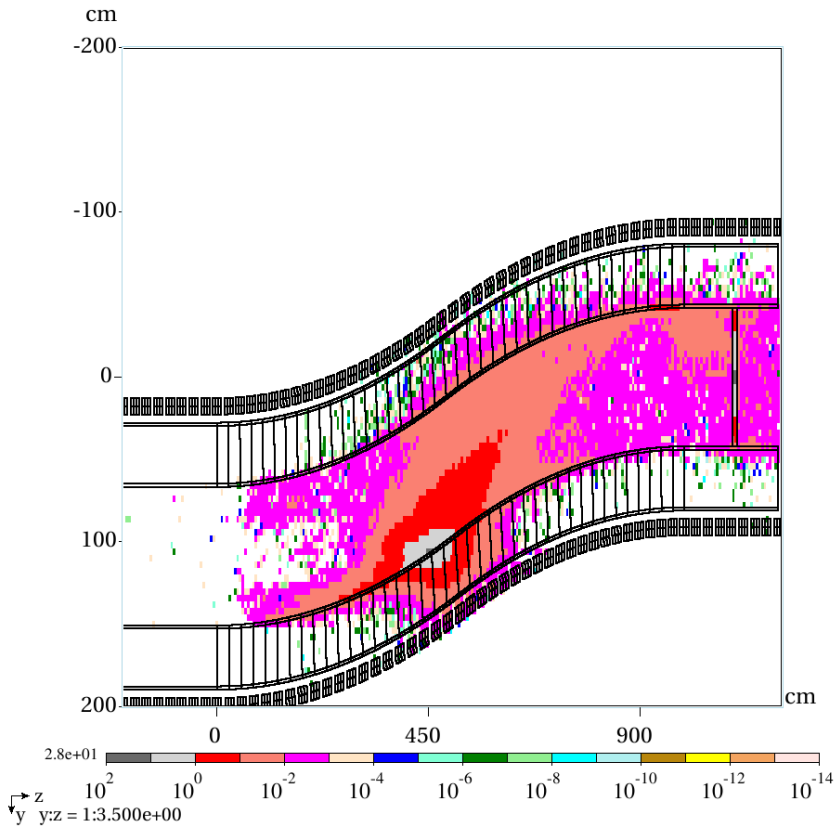


Proton flux, top view

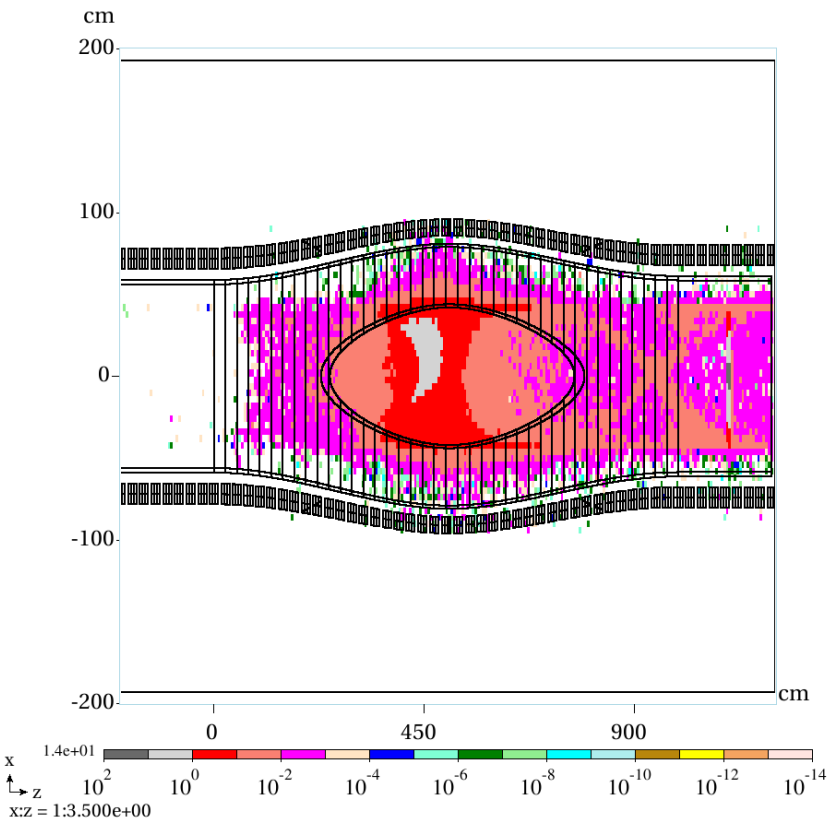


Proton flux, side view

New results 3

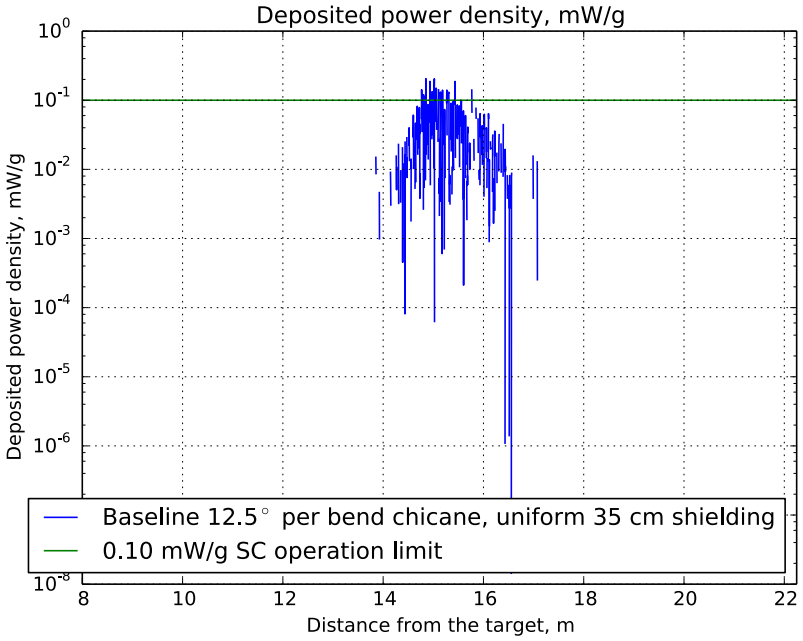


Deposited power density, mW/g, top view

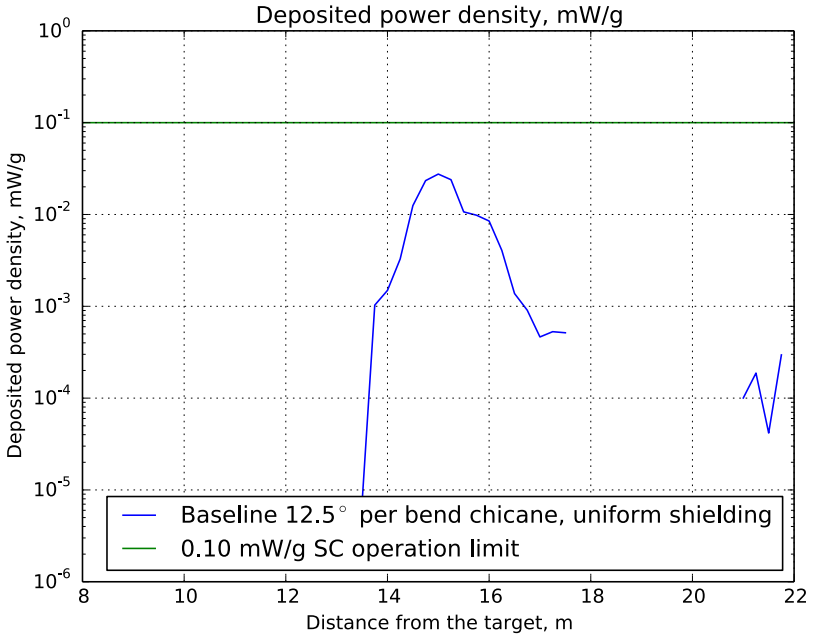


Deposited power density, mW/g, side view

New results 4



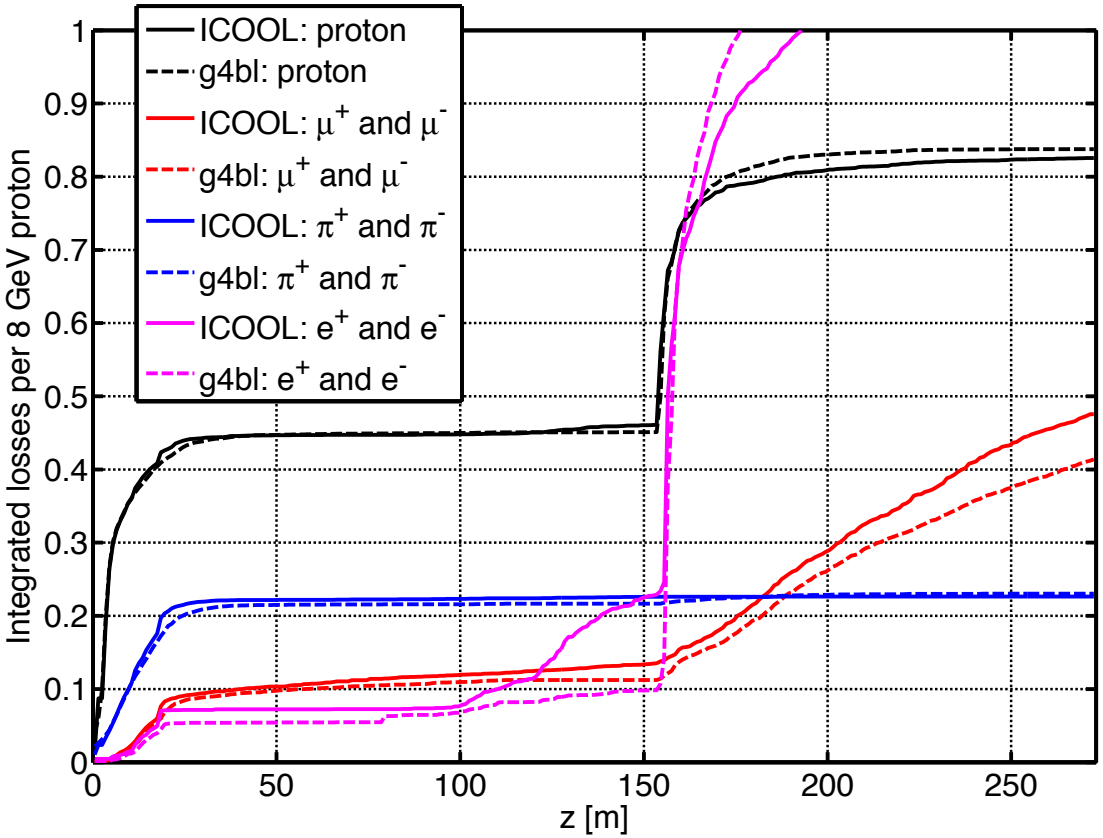
Deposited power density, mW/g
segmented coil analysis



Deposited power density, mW/g
averaged

Other codes

- Can G4beamline or ICOOL be used for energy loss/ deposition calculations?
- Back in 2010 I did a comparison of the two codes for IDR:



Summary

- Simulations of the new 1 MW graphite target are underway, first results presented.
  - power density > 0.1 mW/g only in a handful of cental coils, very low everywhere else;
  - definitely do not need 35 cm of tungsten.
- Action item: implement a more sophisticated geometry (elliptical cross-section following the profile of the beam).
  - this will allow to significantly reduce the amount of W used for shielding.
- MARS is the main tool, although G4beamline and ICOOL can also be used for some analyses.

Thank you!